11p

N64-16330
CODE-1
CR-55756

REDUCTION OF NYSTAGMUS AND DISORIENTATION IN HUMAN SUBJECTS

Frederick E. Guedry, Ashton Graybiel, and William E. Collins

JOINT REPORT

UNITED STATES NAVAL SCHOOL OF AVIATION MEDICINE

AND

THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

OTS PRICE
XEROX $ 1.60 ph
MICROFILM $ 1.80 mf.

U. S. Naval School of Aviation Medicine
U. S. Naval Aviation Medical Center
Pensacola, Florida

SPT-11376

FOR OFFICIAL USE ONLY
MAY BE RELEASED ON
19 JUNE 1962

Research Report

REDUCTION OF NYSTAGMUS AND DISORIENTATION IN HUMAN SUBJECTS*

Frederick E. Guedry, Ashton Graybiel, and William E. Collins

Bureau of Medicine and Surgery
Project MR005.13-6001
Subtask 1 Report No. 69

NASA Order R-47

Released By

Captain Clifford P. Phoebus, MC USN
Commanding Officer

*This research was conducted under the sponsorship of the Office of Life Science Programs, National Aeronautics and Space Administration.

U. S. NAVAL SCHOOL OF AVIATION MEDICINE
U. S. NAVAL AVIATION MEDICAL CENTER
PENSACOLA, FLORIDA

SUMMARY PAGE

THE PROBLEM

The object of this study was to determine the course of adjustment to a rotating environment and to determine transfer of habituation from one vestibular environment to another.

FINDINGS

16330

Nystagmus, disorientation, and nausea were reduced in subjects living and moving about for several days in a slowly rotating room. The reduced nystagmus was not reinstated by assigning "arousal-tasks" which are ordinarily effective in this respect. After rotation was stopped residual effects were noted for several hours. These included compensatory nystagmus, compensatory illusory reactions, and some motion sickness. Other subjects were exposed to similar circumstances for shorter periods wherein only restricted head movements in a particular plane were permitted. Nystagmus, illusory phenomena, and nausea were reduced by this procedure. However, the habituation did not transfer to forms of vestibular stimulation including head movements in an "unpracticed quadrant" which produce reactions similar in direction and plane to those repeatedly experienced during the habituation period. Residual effects from this shorter more restricted exposure were slight.

Author

ACKNOWLEDGMENTS

We gratefully acknowledge the cooperation of the individuals who served as subjects in this study.

INTRODUCTION

Vestibular nystagmus can be reduced when a particular pattern of vestibular stimulation is repetitively administered (2,4,7,9,12,14,15). This reduction may result from loss of arousal or drowsiness (1,2,5,9,11,13,15), but recent experiments (6,10) have indicated that an active suppression involving an opposing response tendency also reduces nystagmus under some experimental conditions.

This distinction is of practical importance as well as theoretical significance. Nystagmus reduction from loss of stimulus arousal value may occur very quickly and is not necessarily indicative either of general adaptation to a complex vestibular environment or a prolonged state of adaptation. The fickle nature of this kind of nystagmus reduction is demonstrated by the ease with which the nystagmus can be reinstated, e.g., by simply requiring the subject to perform some task such as mental arithmetic (1). It is altogether likely that a number of studies of transfer of nystagmus habituation from one stimulus mode to another have been influenced by this factor.

EXPERIMENTAL STUDIES

Nystagmus reduction involving an opposing response tendency (10) appears to remain suppressed in spite of attempts to reinstate it by ordinarily effective methods of arousal (1,10). In a recent experiment (10) seven subjects were rotated almost continuously for 64 hours at 5.4 RPM in a 15-foot diameter rotating room. Normal activities of day-to-day living were carried on within the room, which was fully illuminated during waking hours. However, during periods in which nystagmus was recorded, the room was dark, and particular head movements were executed and recorded. Nystagmus diminished considerably during this 64-hour period, and by the morning of the fourth day was greatly reduced in all subjects. Efforts to maintain alertness by instructions and assignment of simple mental arithmetic tasks did not restore nystagmus. Moreover, head movements in the static condition after the prolonged period of rotation produced a nystagmus opposite in direction to responses produced by the same head movement during rotation, an apparent manifestation of a conditioned competing response.

This kind of nystagmus reduction would probably lead to difficulties in any immediate exposure to a new acceleration environment. This is indicated by the compensatory illusory phenomena, nystagmus, and nausea which were encountered when the subjects returned to the normal static environment (6,10). From these observations and others it is apparent that the success of any attempt to precondition a person for an unusual vestibular environment depends to a large extent upon our understanding of the factors controlling transfer of habituation from one environment to another.

To study transfer effects further, subjects were placed in chairs in the Pensacola Slow Rotation Room, described elsewhere (3), for periods of from four to eight hours. These subjects were permitted to make head movements in the frontal plane only and in only one quadrant of this plane. For example, head movements were sometimes restricted to 45 degrees lateral tilt toward the left shoulder and return to upright. Plane and total angle of head movement were set by a bite-board arrangement which also permitted the movements to be recorded. Between series of head movements subjects gradually moved their heads back against a comfortable headrest and remained motionless relative to the room. Each of three runs consisted of a group of four subjects making several series of 20 head-movement cycles. A cycle consisted of a tilt and a return movement, each position being held for 15 seconds. Total cycles for each group were 100, 140, and 260. Variations in total cycles between groups were due to practical considerations such as available subject-time.

At the beginning and end of the day's run head movements were made in both quadrants, i.e., in the left and right quadrants, to ascertain how much nystagmus reduction would carry over from the "practiced" to the "unpracticed" quadrant. Nystagmus was recorded in complete darkness, but the practiced head movements in the habituation series were made with the room illuminated. Subjects also reported soon after the beginning and just before the end of the run on the apparent motion of a target light in the otherwise dark room to test for changes in the oculogyral illusion (OGI) which might have occurred during the habituation series. All conditioning series and tests at the beginning and end of the run were made while the room rotated in a counterclockwise direction at 7.5 RPM. In addition, before and after the prolonged 7.5 RPM rotation period, tests were made under static conditions, i.e., head movements were made but the room was stationary.

Results are shown in Table I. The nystagmus and OGI tests at the beginning and end of each run provided eight opportunities to test for response decline in each subject, viz., tilt and return stimuli in each of two quadrants for each response variable. Subjects were given mental arithmetic problems during the recording periods to avoid reduction of nystagmus due to the arousal factor. Since this was done only at the beginning and end of the run, there was little possibility of habituation to the mental arithmetic task itself.

It is apparent from Table I that dramatic reductions in response occurred in the practiced quadrant, but these reductions did not carry over to the unpracticed quadrant. This minimal transfer of habituation is particularly significant in view of the fact that OGI and nystagmus responses of approximately the same directions and planes wereproduced by head movements in the two quadrants. For example, tilting the head toward the left shoulder (practiced) produced vertical nystagmus (relative to the skull) with fast phase-up, and returning the head to upright from the right-tilt (unpracticed) produced very nearly the same direction and plane of nystagmus. Similarly, returning the head from the left shoulder to upright (practiced) produced nystagmus-down and an apparent diving sensation, as did tilting the head toward the right shoulder (unpracticed).*

---

* The righthand quadrant was "practiced" in four subjects and the lefthand quadrant was "practiced" in eight subjects.

Table 1

Reductions of Reactions to Head Movements As Indicated by Tests Made During 7.5 RPM Room Rotation at the Beginning and End of the Run

	Categories of Reductions from Beginning to End	Frequency of Occurrence of Reduction Categories: Practiced Quadrant	Unpracticed Quadrant
NYSTAGMUS	Reduction to zero nystagmus	10	0
	Reduction of about 90 percent	11	2
	Reduction of about 50 percent	2	4
	Reduction of 10 percent or less	1	11
	No reduction	0	7
OGI-SENSATION	Reduced to zero	23	5
	Sensation present at end	1	19

The subjective responses and nystagmus were essentially concordant. However, the subjective data, with room stationary after the habituation run, gave more definite evidence of a competing response tendency. Head movements in the practiced quadrant toward the end of the period of rotation no longer produced a subjective reaction. For some time after rotation, the same head movements yielded a reversed reaction. Conversely, head movements in the unpracticed quadrant near termination of the rotation run still produced a reaction but subsequently under static conditions did not yield subjective effects. These findings are illustrated in Figure 1.

Eye movements recorded under static conditions showed evidence of a similar nature, but the nystagmus thus produced was not consistent. However, it is presumed that, with longer rotation exposure, the competing response tendency would have been clearly evidenced by nystagmus as it was in the 64-hour run previously reported.

DISCUSSION

Reduction of a vestibular response by frequent repetition of one stimulus pattern does not necessarily transfer to another stimulus pattern which also initially elicits the same response. For example, during rotation of the room, the illusion of "nosing over" and vertical nystagmus with fast phase-down were produced by returning the head to vertical from a left tilt position. Essentially the same response was produced by lateral head-tilt toward the right shoulder. After repeated head movements in the left quadrant the nystagmus and illusion disappeared, but head tilt to the right still produced nystagmus-down and the illusion of "nosing over."

The reduction in the practiced quadrant is apparently attributable to a conditioned competing response tendency. Several possible conditioned stimuli deserve consideration. The otolith system, the proprioceptors of the neck, and the intention involved in the head movement all could be conditioned to signal a particular pattern of discordant influx from the canals and to release a competing response. Head movements in the unpracticed quadrant would not involve the same pattern of conditioned stimuli and the competing response would not be released. Hence, toward the end of the run during rotation, the practiced head movements elicit a sensory influx which is matched by a central competing response pattern and the nystagmus and illusion are suppressed.

In subsequent static tests, the practiced head movements still release the conditioned competing response which is manifest by a sensation of climbing and, in the 64-hour run, by a vertical nystagmus with fast phase-up. Conversely, in the unpracticed quadrant, head movements made toward the end of the rotation period still produce the illusion of "nosing over" and nystagmus-down and fail to produce effects in the subsequent static tests. Both results, rotation tests and static tests, suggest the presence of a conditioned competing response which is specific to the pattern of conditioned stimuli. The possibility that the results could be attributed to arousal effects seems remote in view of the assigned tasks to control

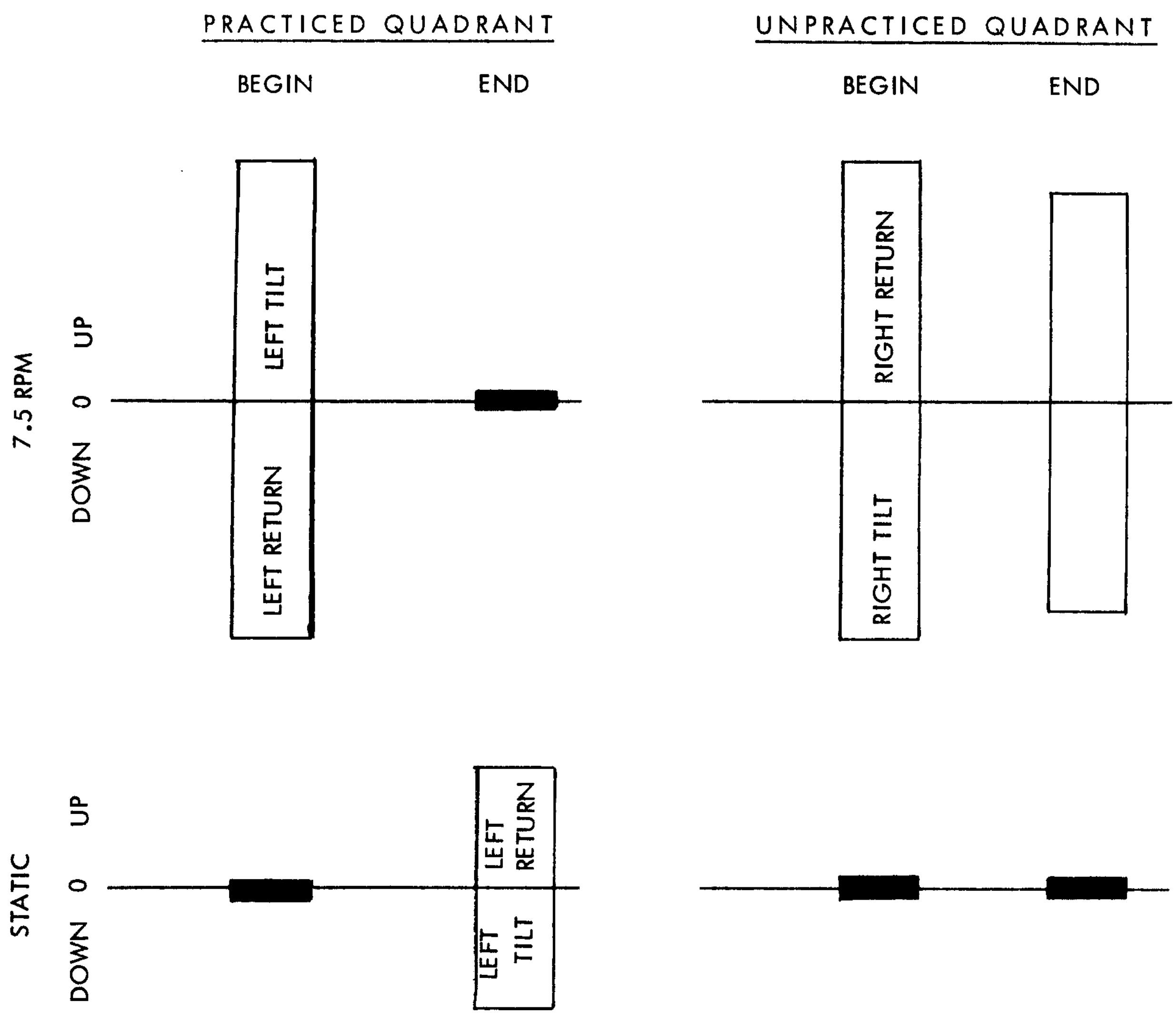

Figure 1

Schematic Illustration of OGI-sensation Findings this factor and the reversal of effects in the static tests.

In the other experiment in which subjects lived for 64 hours aboard the rotating room, evidence of competing responses in both quadrants was to be expected because movement was unrestricted, and although a bizarre pattern of sensory input accompanied almost every head movement, the bizarre pattern was very consistent. Hence, any particular movement from any one position produced a unique pattern of discordant sensory influx which made possible the conditioning of a specific set of compensatory responses.

This would not be true aboard ship or in aircraft because of the highly variable vestibular environments present. Any particular head movement relative to the ship would not always occur during a particular motion of the ship. Hence, a given head movement relative to the ship could not become associated with a unique sensory pattern and would be unlikely to elicit a consistent (and hence, demonstrable) compensatory reaction when the ship is subsequently motionless. Although the shipboard exposure would not be so favorable as continuous rotation for demonstrating a consistent compensatory reaction, it is not unlikely that sensory influx from particular ship movements could combine with central nervous system patterning preparatory to voluntary head movement to actively suppress discordant vestibular patterns. Groen (8) has suggested a highly dynamic suppression of complex character and adduces as evidence the occasional persistent subjective motion aftereffects of a rough sea voyage.

The development of active suppression may be dependent upon complex situations, such as those of the present experiments and shipboard experience, which involve discordance among various aspects of the sensory patterns and also voluntary active movements of the head and body. Repeated passive rotation about a fixed vertical axis of rotation, with head and body fixed relative to the axis of rotation, may not be propitious for the development of active suppression of vestibular responses. In this situation there would be little or no opportunity for either voluntary "commands to action" or naturally paired otolith and proprioceptor impulses to signal and become conditioned to discordant canal input.

Much more experimental data are essential, but it is suggested that a highly variable vestibular environment involving active voluntary movements of the head and body may provide the most desirable conditioning procedure for the future space traveler from the point of view of establishing desirable habituation transfer effects.

REFERENCES

1. Collins, W. E., and Guedry, F. E., Arousal effects and nystagmus during prolonged constant angular acceleration. Acta otolaryng., Stockh., 54: 349-362, 1962.

2. Crampton, G. H., and Schwam, W. J., Effects of arousal reaction on nystagmus habituation in cat. Amer. J. Physiol., 200: 29-33, 1961.

3. Clark, B., and Graybiel, A., Human performance during adaptation to stress in the Pensacola slow rotation room. Aerospace Med., 32: 93-106, 1961.

4. Dodge, R., Habituation to rotation. J. exp. Psychol., 6: 1-35, 1923.

5. Duensing, F., and Schaefer, K. P., Die "locker gekoppelten" Nerone der Formatio reticularis des Rhombencephalons beim vestibulären Nystagmus. Arch. f. Psychiat. u Zeit Neurol., 196: 402-420, 1957.

6. Graybiel, A., Guedry, F. E., Johnson, W. H., and Kennedy, R., Adaptation to bizarre stimulation of the semicircular canals as indicated by the oculogyral illusion. Aerospace Med., 32: 321-327, 1961.

7. Griffith, C. R., The organic effects of repeated bodily rotation. J. exp. Psychol., 3: 15-46, 1920.

8. Groen, J. J., Problems of the semicircular canals from a mechanico-physiological point of view. Acta otolaryng., Stock., Suppl. 163, 1960.

9. Guedry, F. E., Collins, W. E., and Sheffey, P. L., Perceptual and oculomotor reactions to interacting visual and vestibular stimulation. Perceptual and Motor Skills, 12: 307-324, 1961.

10. Guedry, F. E., and Graybiel, A., Compensatory nystagmus conditioned during adaptation to living in a rotating room. J. appl. Physiol., 1962. Accepted for publication.

11. Guedry, F. E., and Lauver, L. S., Vestibular reactions during prolonged constant angular acceleration. J. appl. Physiol., 16: 215-220, 1961.

12. Mowrer, O. H., The modification of vestibular nystagmus by means of repeated elicitation. Comp. Psychol. Monogr., 9: 1-48, 1934.

13. Sharpless, S., and Jasper, H., Habituation of the arousal reaction. Brain, 79: 655-680, 1956.

14. Wendt, G. R., An interpretation of inhibition of conditioned reflexes as competition between reaction systems. Psychol. Rev., 43: 258-281, 1936.

15. Wendt, G. R., Vestibular functions. In Stevens, S. S. (ed.): Handbook of Experimental Psychology. New York: John Wiley and Sons, Inc., 1951.